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ENVIRONMENTAL INVESTIGATIONS OF DREDGING ACTIVITIES IN MOBILE BAY, ALABAMA

Technical Committee for Analysis of Mobile Bay Dredging

Prepared for:

Environmental Protection Agency

July 1973

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Final Report of THE TECHNICAL COMMITTEE FOR ANALYSIS OF MOBILE BAY DREDGING July 1973

Prepared for
The Conferees of the January 27-28, 1970,
Conference "In the Matter of Pollution
of the Navigable Waters of Mobile Bay
and Its Tributaries"

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INTRODUCTION

During the enforcement conference held in Mobile, Alabama, on January 27-28, 1970, it became apparent that very little specific information or technical environmental data concerning the effects of dredging operations in Mobile Bay were available. As a result, the conferees included in their recommendation No. 7 that a Technical Committee be established to analyze dredging in Mobile Bay. The conferees named the following agencies to comprise the committee and the committee was formed in June 1971.

TECHNICAL COMMITTEE MEMBERS

- ALABAMA DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES
- ALABAMA WATER IMPROVEMENT COMMISSION
- FEDERAL WATER POLLUTION CONTROL ADMINISTRATION (NOW ENVIRONMENTAL PROTECTION AGENCY)
- U. S. CORPS OF ENGINEERS, MOBILE DISTRICT

The following additional organizations were invited to participate in the workings of the committee.

- Bureau of Sport Fisheries and Wildlife, U. S. Department of the Interior
- Geological Survey of Alabama
- Marine Science Programs, University of Alabama
- South Alabama Regional Planning Commission
- Waterways Experiment Station, Corps of Engineers

The committee's initial approach in analyzing dredging in Mobile Bay was to determine the extent of existing and proposed dredging operations,

review available data, and conduct a base-line environmental study. Concurrently, some of the agencies, in recognition of the problem, were already involved in detailed studies pertaining to dredging. In addition, participating agencies of the committee funded further investigations.

This final report summarizes the results of the following studies conducted under the auspices of the Technical Committee. Specific data sources drawn upon by the committee are referenced in these reports.

Base Line Environmental Investigation, Dredging Activities, Mobile Bay, Alabama, (August 1972), A Progress Report of the Technical Committee, Analysis of Mobile Bay Dredging.

The Ecological Consequences of Channel Dredging in D'Olive Bay, Alabama, (Manuscript) Barry A. Vittor, University of Alabama Marine Science Programs.

Environmental Effects of Hydraulic Dredging in Estuaries, (In Press), Alabama Marine Resources Bulletin 9, Edwin B. May, Alabama Department of Conservation and Natural Resources, Marine Resources Division.

Extensive Oxygen Depletion in Mobile Bay, Alabama,(In Press) Limnology and Oceanography, Edwin B. May, Alabama Department of Conservation and Natural Resources, Marine Resources Division.

Final Environmental Statement - Permit Application By Radcliff Materials, Inc., Dredging of Dead-Reef Shells, Mobile Bay, Alabama, (February 1973),U. S. Army Engineer District, Mobile, Alabama.

SUMMARY AND CONCLUSIONS

Mobile Bay is a large, shallow bay situated at the mouth of an extensive river system, draining approximately 44,000 square miles. The 248,900 acres of water surface is spread over an area approximately 27 nautical miles long by 11 miles wide; the average depth is about 9.7 feet. Traversing the length of the bay is a navigation channel 400 feet wide and 40 feet deep.

Generally, the tidal cycle in the bay is diurnal. Although tidal cycles exhibit seasonal fluctuations, the mean tidal range in Mobile Bay varies from 1.5 feet at the head to 1.2 feet at the entrance. Tidal flooding of the bay exhibits a distinctive movement toward the eastern shore. A counterclockwise movement is the predominant feature of the current and salinity patterns of the bay during low flow conditions.

Industrial and urban development of the area have placed additional demands on the resources of the bay and have induced changes which have altered its productivity. Within a geological time frame, the bay will ultimately be filled by marsh, tidal flat and deltaic deposits. However, the development of the Battleship Parkway (U. S. Highway 90) across the upper bay has created an artificial barrier separating the Mobile River Delta and Mobile Bay and has possibly altered the physical aspects of the upper portion of the bay much more than would have occurred naturally during the same length of time. Construction and maintenance of the Mobile Ship Channel and the smaller channels within the bay and

the dredge and fill activities around the periphery of the bay have played a significant role in physical alteration of the bay and estuary.

An annual average of 4.7 million tons of suspended sediment and an unknown quantity of bed load are currently being transported into the estuary, of which approximately 1.4 million tons pass through the estuary and are deposited to the south and west of the tidal inlets. Sediment encroachment in the bay is a gradual, continuous occurrence. Deposition of sediment over thousands of years has buried once existing oyster reefs under 1 to 30 feet of overburden. These reefs are now being mined for commercial purposes. Currently, oyster production in the bay is confined to 3,064 acres of natural oyster reefs, 924 acres of leased bottoms, and 1,050 acres of riparian bottoms used for growing oysters in Alabama. Because of bacterial pollution, more than 73,000 acres of Mobile Bay are permanently closed to shellfish harvest and the remainder of the bay is subject to temporary closure when the total coliform density exceeds the Shellfish Sanitation Standard of 70 MPN per 100 ml.

Non-federal dredging activities in Mobile Bay are conducted under permitting procedures of the Corps of Engineers. Environmental issues associated with this activity, as well as federal projects, are reviewed by the U. S. Environmental Protection Agency, U. S. Bureau of Sport Fisheries and Wildlife, National Marine Fisheries Service, Alabama Department of Conservation and Natural Resources, Alabama Water Improvement Commission, and local and private groups concerned with the

protection and enhancement of the environment. Additional regulation and control of shell dredging in state-leased land in the bay is the responsibility of the Alabama Department of Conservation and Natural Resources.

Initially, the committee formed to analyze dredging activities in Mobile Bay made a study to compare the sediment in the bay with suggested EPA criteria for open-water disposal of dredge spoil. A limited water quality investigation of the shell dredge was also conducted. Results of the sediment analyses disclosed that 26 of 33 sampling locations exceeded EPA's suggested criteria for open-water spoil disposal, but other analyses indicated that pesticides and polychlorinated biphenyls do not appear to be a problem in sediments within the confines of Mobile Bay. Tentative conclusions were drawn from the sediment and water quality studies, but the data were not adequate to accurately determine environmental effects of dredging on water quality and aquatic life.

The major conclusion of the committee's initial study was that the suggested dredging criteria of EPA were established without factual data as to regional water quality or biological considerations. The committee, in its August 1972 progress report to the enforcement conference conferees, recommended that the criteria be reevaluated and that the development of realistic dredging criteria be accomplished on a regional basis through the cooperation and assistance of federal and state agencies.

The initial study raised numerous questions and pointed out the need for additional studies to assess the effects of dredging activities

on the ecology of the bay. Investigations were conducted to study shell dredging, channel maintenance dredging, new channel construction and diked disposal. The committee's summary and conclusions drawn from these studies are as follows.

Shell Dredging

Open-water shell dredging, as conducted in Mobile Bay, does not create deep channels and associated spoil banks, although the operation occasionally leaves isolated mounds. Consequently, shell dredging operations in Mobile Bay do not appreciably affect the overall circulation patterns of the bay.

Increases in turbidity above ambient as a result of shell dredging are usually localized, affecting a relatively small part of the bay. Surface turbidities in dredging operations have been documented to approach normal levels within 1,200-1,500 feet from the point of discharge. Periodically, increases in turbidity over more extensive areas of the bay are caused by natural conditions such as wind-induced mixing and high river flows. Bottom trawling activities also contribute to short-term turbidity increases during certain times of the year.

Levels of suspended solids were observed to exceed ambient a maximum of 2,000 to 2,800 feet from the dredge. An identifiable mud flow was observed to extend 1,600-2,000 feet from the dredge.

The mud flow covers the original bottom from one to several inches, smothering organisms incapable of migrating through it. Substantial numerical recovery of the benthic fauna in dredged cuts occurs within

two months to two years. However, species diversity may be decreased for a longer time.

Dredging was not observed to increase dissolved concentrations of most inorganic and organic sediment components, including metals.

Dissolved oxygen is little affected, except very near bottom in the mud flow in the area of high total suspended solids. Dissolved oxygen at surface and mid-depth was observed to be only slightly depressed.

The pH is little affected as a result of dredging. There appeared to be a limited increase in total dissolved phosphorus in certain situations.

Oyster shell from the operation is partly used for cultch on public bottoms, thereby increasing oyster production.

Shell dredging should continue to be closely supervised as to area of operations in regard to shoreline, oyster bottoms, and navigation structures. If proper precautions are taken to avoid damage to oyster beds, effects of shell dredging on water quality, substrate, and resident biota are temporary.

Channel Maintenance Dredging

Channel maintenance dredging is conducted on a frequent, intermittent basis. Except for physical modifications associated with channel construction and maintenance dredging spoil disposal methods, the water quality and biological effects are generally similar to those discussed for shell dredging.

Construction and to a lesser extent maintenance dredging of the Mobile Ship Channel have created spoil banks parallel to the ship channel which are extensive in the upper part of the bay. These barriers may affect the development of cross-currents and, thereby, influence the circulation patterns within the bay.

During summer months, dissolved oxygen is depressed or depleted in large areas of bottom water in Mobile Bay. The depressed oxygen concentrations result from salinity stratification, decomposition of organic materials, and the lack of exchange of water masses under certain conditions. The bathymetry of Mobile Bay prior to major alteration by construction of the ship channel indicates that the bay was relatively flat, sloping gently toward its mouth. Current bathymetric data show large shallow depressions in the bay bottom bounded by spoil from construction of the ship channel and shoaling in the lower bay. These depressions are slightly deeper than surrounding waters. The ship channel, spoil banks, and shoaling in the lower bay appear to emphasize conditions which could permit salinity stratification and deteriorated water quality. However, the apparent existence of depressed dissolved oxygen conditions prior to the construction of the ship channel indicates that the present physical modifications to the bay are not the sole causes of existing water quality conditions.

New Channel Construction (D'Olive Bay)

Although sediment in D'Olive Bay, which was disposed of in a diked land area, exceeded EPA suggested dredging criteria for open-water disposal, hydraulic dredging did not significantly affect the water quality

of D'Olive Bay. Observations taken in the vicinity of the channel dredge indicated that circulation patterns, water temperature, dissolved oxygen, salinity and turbidity were not affected.

Natural conditions had a greater short-term impact on the bay environment than did channel dredging. The major adverse consequence of the project was the destruction and disruption of nearly 13 acres of benthic communities in the channel path. Additionally, benthic communities in approximately 7 acres of the bay were covered and destroyed when a dike failure released spoil into the bay. The benthic animal biomass in the affected areas was 28 percent lower than at control stations at least eight months after dredging.

Diked Spoil Disposal

Much of the data for the diked spoil disposal study is not currently available for complete analysis; therefore, the committee drew no conclusions from the data. The dike failure which occurred during the D'Olive Bay study and other dike failures and spoil area management problems not directly associated with the committee's efforts point out the need for more stringent regulation, inspection, and supervision of diked disposal.

RECOMMENDATIONS

It is recommended that:

1. The U. S. Environmental Protection Agency reevaluate its suggested dredging criteria for open-water spoil disposal. During reevaluation, it is further recommended that:

   - Necessary studies be made to determine the existence and effects, if any, of the transfer mechanisms of constituents in sediment to water and aquatic organisms. This work, having nationwide application, should be funded or performed at the national level by appropriate agencies.

   - In view of differing water quality conditions which may exist in geological, physical, chemical and biological characteristics from area to area, dredging criteria be established on a geographic basis in cooperation with the regional federal and state agencies.

   - Consideration be given to evaluating the importance of additional parameters not presently included in the EPA suggested criteria.

2. Funding be provided by the Corps of Engineers (Waterways Experiment Station and Mobile District); U. S. Environmental Protection Agency, Region IV; Bureau of Sport Fisheries and Wildlife; Alabama Department of Conservation and Natural Resources, Marine Resources Division; and National Marine Fisheries Service to conduct studies in Alabama to determine:

   - The effect of physical changes from channel dredging and spoil disposal on water circulation, oxygen depletion, and salinity intrusion by use of the hydraulic model at the Waterways Experiment Station and supporting field studies.

   - The chemistry of water and sediments and their organic and inorganic oxygen demand.

   - The effects of low dissolved oxygen and salinity intrusion on aquatic and benthic organisms and on nutrient chemistry.

   - Possible beneficial methods of spoil disposal and uses of spoil.

3. Open water spoil disposal from channel dredging be conducted so that resulting spoil deposits do not adversely restrict water circulation. Where it has been demonstrated that existing spoil deposits significantly restrict water circulation which adversely affects water quality, that these deposits be modified to restore adequate circulation.

4. A moratorium not be declared on all types of dredging in Mobile Bay, but that the individual and accumulative environmental effects of each dredging project be considered on a case by case basis.

5. A committee be formed to consist of the Environmental Protection Agency (Region IV), Mobile District Corps of Engineers, Alabama Water Improvement Commission, Alabama Department of Conservation and Natural Resources, Bureau of Sport Fisheries and Wildlife, and National Marine Fisheries Service to develop adequate design and operation criteria for diked spoil disposal systems, and that the committee develop proper inspection and monitoring procedures to be implemented by these agencies.

BACKGROUND

Mobile Bay (Figure 1) is situated at the mouth of an extensive river system with a drainage basin of 44,000 square miles consisting of about 64 percent of Alabama, and parts of Georgia, Mississippi, and Tennessee. Principal rivers in the basin are the Mobile, Tombigbee, Black Warrior, Alabama, Coosa, and Tallapoosa.

The Mobile area is located in the Southern Pine Hills and Coastal Lowlands of the East Gulf Coastal Plain section of the Coastal Plain Physiographic Province. The underlying terrigenous rock strata dip southward about 40 feet per mile. The flood plain of the Mobile River extends north-south through the center of this division, and ranges from 6 to 11 miles in width, and from 5 to 30 feet above mean sea level (msl). West of the flood plain, a ridge consisting of a series of flat-topped hills rising from 200 to 330 feet msl forms the divide between the Mobile and Escatawpa River basins. To the east, a similar divide with the Escambia River Basin extends through the center of Baldwin County.

The Gulf of Mexico has a substantial influence on Mobile's moist and nearly sub-tropical climate. Winters are mild and summers are warm. January is the coldest month of the year, with a normal daily minimum of about 44°F and a normal daily maximum of about 62°. July is the warmest month with a normal daily minimum of about 73° and a normal daily maximum of about 92°. The annual rainfall of 68 inches is among the highest in the United States.

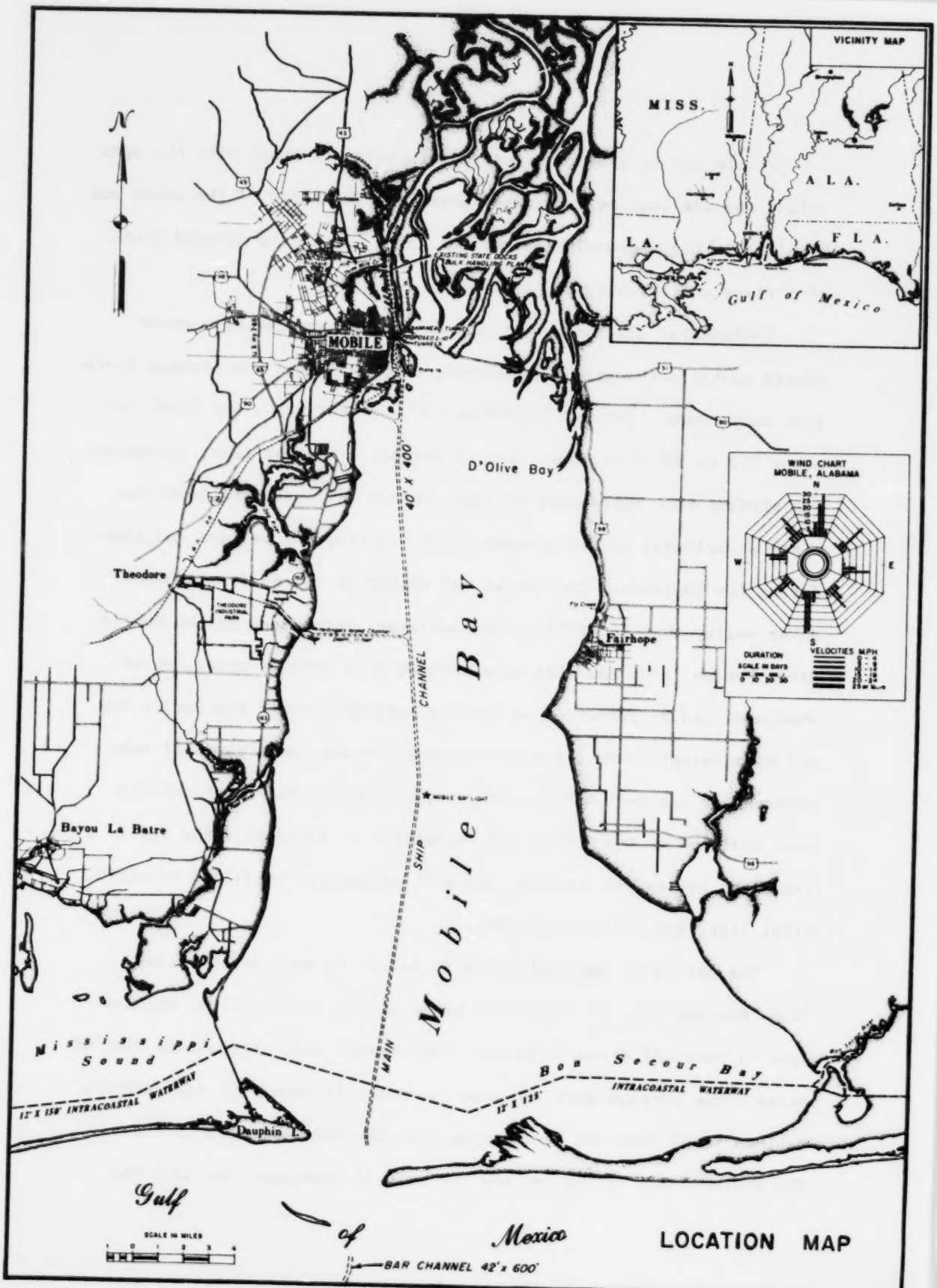
VICINITY MAP
MISS.
ALA.
LA.
FLA.
Gulf of Mexico
N
MOBILE
D'Olive Bay
40' X 400'
Theodore
Fairhope
WIND CHART
MOBILE, ALABAMA
DURATION
SCALE IN DAYS
VELOCITIES M.P.H.
SHIP CHANNEL
Mobile Bay
MAIN
Bayou La Batre
Mississippi Sound
12' X 150' INTRACOASTAL WATERWAY
Bon Secour Bay
INTRACOASTAL WATERWAY
12' X 125'
Dauphin I.
Gulf of Mexico
SCALE IN MILES
BAR CHANNEL 42' x 600'
LOCATION MAP

FIGURE 1

Mobile Bay is a large estuary, triangular in shape with the apex inland and the long axis oriented normal to the trend of the shore and parallel to the regional slope of the land. It is the drowned mouth of a river valley, possibly a graben.

Continental glaciation during the Pleistocene geologic epoch caused eustatic changes in sea level, which modified the Alabama shoreline many times. Between 17,000 and 20,000 years ago, sea level was about 350 to 375 feet lower than at present. At that time, the existing streams were entrenched in deep, narrow valleys. Sea level has risen erratically to its present level, filling the valleys and inundating the lowlands. The Mobile Bay Estuarine System is a drowned river valley that is filling from sediments introduced by the Mobile River System. The lowlands were covered by a body of water, which when modified by formation of barrier islands, formed Bon Secour Bay and Mississippi Sound. Eustatic changes in sea level have not been apparent in the past 4,000-5,000 years, although the coastline has been modified by the influx and deposition of sediment. The bay is a transient geological feature, and will ultimately be filled by marsh, tidal flat, and deltaic deposits.

The bay is 27 nautical miles in length to Battleship Parkway (U.S. Highway 90), 19.8 nautical miles at its widest point, and averages 11 nautical miles in width. The overall area encompasses 248,900 acres. The average depth at mean low water is about 9.7 feet and the maximum is 60 feet off Fort Morgan near the Gulf entrance to the bay. The southern end of the bay has two natural openings, one into the

Gulf of Mexico at the main pass, and another on the western side into Mississippi Sound. A dredged channel, part of the Gulf Intracoastal Waterway, extends from Mississippi Sound to Bon Secour Bay, linking Mobile Bay and Perdido Bay, Alabama-Florida.

The bay receives fresh water principally from the Mobile River System which is formed by the union of the Alabama and Tombigbee Rivers. The Mobile River flows as a single stream for only about 5 miles below the Alabama-Tombigbee confluence before entering the deltaic flood plain to the north of the bay where it branches into distributaries. The average annual flow into the bay from the Mobile River System is about 59,000 cubic feet per second (cfs). Although several small rivers and streams enter Mobile Bay below Battleship Parkway, their flow is quite small.

The tidal cycle in Mobile Bay is diurnal, usually with one high and one low tide in a twenty-four hour period. During the bi-weekly neap tides, however, two highs or two lows occur within one day. The mean diurnal tidal range in the bayous and inlets along the Alabama coast varies from approximately 1.8 to 0.6 feet. The mean tidal height in Mobile Bay varies from 1.5 feet at the head of the bay to 1.2 feet at the entrance. Since Mobile Bay is long and fairly wide, the tides are often overcome or accentuated by local winds. Tidal cycles also exhibit seasonal fluctuation. Mean low water in the winter varies from 1.0 to 0.5 feet below that of the summer. The weighted mean tidal range of the bay, 1.4 feet, and the surface area of the bay, produce a tidal prism of about 330,000 acre-feet.

Tidal movement in Mobile Bay is a continuation of the Gulf of Mexico tidal cycle, which is reflected in the bay and its tributaries. Tidal flooding of the bay generally exhibits movement toward the eastern shore. A counterclockwise movement is the predominant feature of the current and salinity patterns of Mobile Bay during low stream flow. Spoil banks paralleling the ship channel, which are extensive in the upper part of the bay, may act as barriers preventing the development of cross-currents and, thereby, exert considerable influence upon the circulation patterns within the bay. Earlier work, based on very meager data, has indicated that the main pass between Fort Morgan and Dauphin Island handles approximately 3/4 of the total volume of water flushed into or out of Mobile Bay and the remaining 1/4 passes through Mississippi Sound.

The construction of the landfill for Battleship Parkway across the upper bay has created an artificial barrier separating the Mobile River Delta and Mobile Bay. The causeway modified the discharge from rivers into the bay and has possibly altered the physical aspects of the upper portion of the bay much more than would have occurred naturally during the same length of time. Construction and maintenance dredging of the Mobile Ship Channel and the smaller channels surrounding the bay and the dredge and fill activities around the periphery of the bay have also played a significant role in physical alteration of the bay and estuary.

Wind plays an important role in the mixing of Mobile Bay. Winds in excess of 15 knots place a large quantity of suspended material within the water column. A 25-knot wind has been recorded as placing

150-200 milligrams per liter (mg/l) of suspended material into Mobile Bay waters. Wind velocities in excess of 24 knots occur approximately 50 days out of each year.

Bay water temperature generally ranges from about 10°C in January to about 31°C in August. The annual average temperature is approximately 22°C, and there is about a one degree difference between top and bottom. Bay salinities are generally low from January to May and range from 15 parts per thousand (15°/oo) in the southern bay to less than 5°/oo in the northern part. During seasonal floods, salinities are depressed far below these values almost uniformly throughout the bay. Salinities increase during June to November and range from 30°/oo in the southern part to 10°/oo in the northern part of the bay.

Dissolved oxygen concentrations in the upper water column generally average about 7 mg/l. Dissolved oxygen in the bottom 2 or 3 feet is frequently much lower or totally depleted in summer over large parts of the bay. In an event, locally known as a "jubilee", which occurs during the summer, mostly along the eastern shore of Mobile Bay, bottom dwelling animals are driven to the shore in large numbers. This occurs when a rising tide combined with gentle offshore winds moves surface water offshore replacing it by oxygen deficient water originating from a section of deeper water in Mobile Bay. The oxygen deficient water apparently originates when more saline waters remain stationary in this deeper portion of the bay and where the decaying of organic debris deposited by the river system gradually depletes the oxygen.

A previous study which included nine stations distributed throughout Mobile Bay, revealed that total phosphorus averaged 77.5 micrograms per liter (ug/l). Nitrate-nitrogen averaged 67.3 ug/l while nitrite-nitrogen averaged 0.7 ug/l. Turbidity averaged 22.3 Jackson Turbidity Units (JTU).

Sediment characteristics are also important to the estuarine environment. The natural sources of sediment deposited in the estuarine system are (1) sediment influx from rivers and streams discharging into the estuary, (2) sediment eroded from the margin of the estuary, (3) sediment entering the estuary from the adjacent marine and estuarine environments by tidal and wind driven currents, and (4) biological processes generating organic debris (floral and faunal) within the marsh-estuary system.

Man-caused modifications of the natural sedimentation processes are related to (1) change in sediment influx into the estuary by both water conservation and agricultural practices, (2) modification of the circulation in the estuary by construction of landfill causeways and landfill residential sites, and creation of spoil banks adjacent to navigation channels, (3) resuspension of sediment by dredging navigation channels and oyster shells, and (4) introduction of wastes from municipal and industrial sources.

Clay, silty clay, and clayey silt comprise the majority of Mobile Bay bottom sediments. Around the periphery of the bay, in waters less than six feet deep, sediments consist principally of sand.

An annual average of 4.7 million tons of suspended sediment and an unknown quantity of bed load are currently being transported into the estuary. Annually, approximately 1.4 million tons of suspended sediment are passing through the estuary and being deposited to the south and west of the mouth of the bay. Sediment deposition is also causing a progradation of the bay-head delta.

There are 3,064 acres of natural oyster reefs, 924 acres of leased bottoms and 1,050 acres of riparian bottom used for growing oysters in Alabama. The majority of these areas are in Mobile Bay. During 1969, 461 people regularly participated in the fishery, which is strongly affected by the pollution of Mobile Bay. More than 73,000 acres of Mobile Bay are permanently closed to shellfish harvest and the remainder of Mobile Bay is subject to temporary closure by the Alabama Department of Health when the total coliform count exceeds 70 most probable number (MPN) per 100 milliliters (ml) in accordance with Shellfish Sanitation Standards. Historically, the Alabama waters of Mississippi Sound have never been closed. Figure 2 shows the classification of Alabama waters with respect to shellfish harvesting. There are 13.2 acres of oyster beds located in the permanently closed area. The permanently closed area has been under surveillance by the Alabama State Health Department since the early 1930's. The location of the closure line became a matter of record in 1952 (Figure 2).

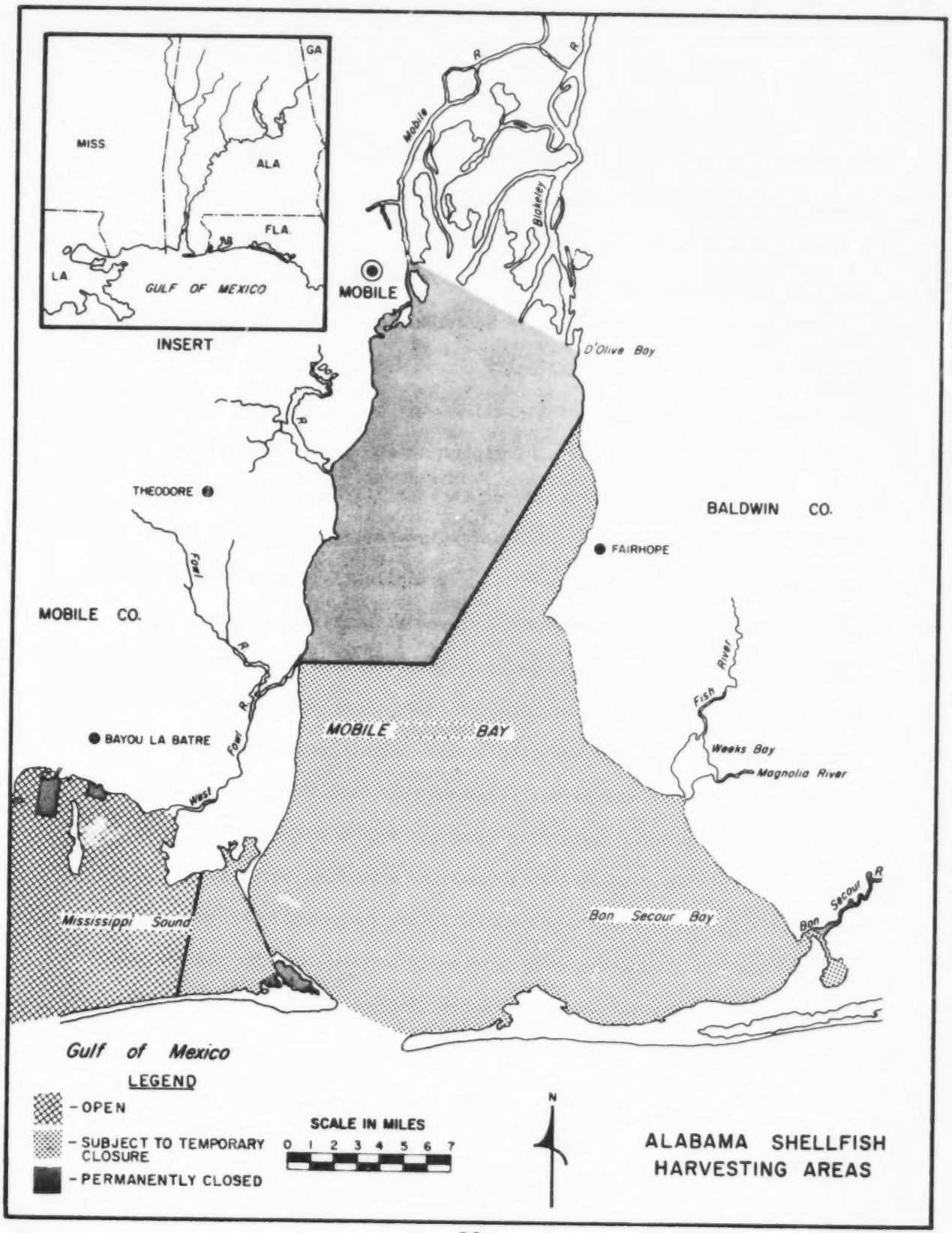
GA
MISS
ALA
FLA
LA
GULF OF MEXICO
INSERT
Mobile R
Blakeley R
MOBILE
D'Olive Bay
Dog R
THEODORE
Fowl R
MOBILE CO.
BALDWIN CO.
FAIRHOPE
Fish River
Weeks Bay
Magnolia River
BAYOU LA BATRE
West Fowl R
MOBILE BAY
Mississippi Sound
Bon Secour Bay
Bon Secour R
Gulf of Mexico
LEGEND
- OPEN
- SUBJECT TO TEMPORARY CLOSURE
- PERMANENTLY CLOSED
SCALE IN MILES
0 1 2 3 4 5 6 7
N
ALABAMA SHELLFISH HARVESTING AREAS

FIGURE 2

TYPES OF DREDGING IN ALABAMA

A list of current dredging projects conducted in the Mobile area is given in Table I. In Mobile Bay, the hydraulic suction dredge is the most frequently used type of dredge. A hopper dredge is used outside the bay entrance in the Gulf of Mexico and mechanical clam-shell or dragline dredges may be used by private contractors in small operations. Following are descriptions of various types of dredges.

HYDRAULIC SUCTION DREDGES

A hydraulic suction dredge, commonly called a pipeline dredge, consists of a large centrifugal pump mounted on a specially designed barge. Bottom materials are brought up to the pump through a large suction pipe. In the case of channel dredges, spoil is pumped from the dredge to the disposal area through a pipeline. Shell dredges discharge over the stern into the cut from which the shell and over-burden are removed.

The suction pipe is lowered to the bottom on a large hinged ladder that extends forward from the bow of the barge. The dredging depth is controlled by cables that can raise or lower the ladder. The bottom of the suction pipe is generally equipped with a revolving cutter-head that breaks up the bottom materials so that they can be drawn into the suction pipe. The cutter-head is turned by a shaft that extends down the ladder from a power source on the barge.

The dredge pump is usually a large-capacity, single-stage centrifugal type that has sufficient clearance to pass anything that can move through the openings in the cutter-head and enter the suction pipe.

Table I

MOBILE BAY AREA DREDGING PROJECTS
April 1973

ACTIVE PERMITS

Mobile Bay

Radcliff Materials, Inc.

R. E. Davis

Mobile River

Mobile Tunnel Contractors

Alabama State Docks

Walsh Stevedoring Co.

U. S. Coast Guard

Amerada Hess Corp.

Alabama Drydocks & Shipbuilding

Alabama Highway Department

Chevron Asphalt

Texaco, Inc.

Bayou La Batre

City of Bayou La Batre

Mastercraft Repairs, Inc.

Offshore Trawlers, Inc.

PENDING PERMIT APPLICATIONS

Mobile Bay

J. B. Pittman

Grand Hotel Co.

City of Mobile (Garrows Bend-Arlington Channel)

Mobile River

Miller Oil Purchasing Co.

Lapeyrouse Grain Corp.

Bayou La Batre

Seafood Haven

Seaman Fisheries, Inc.

G & G Boats

Lyons Seafood

Bon Secour River

G. A. Brown

Magnolia Land Co.

Ewing Boat Yard

Perry A. Hand Surveying Co.

Dauphin Island

Eighth Coast Guard District

FEDERAL MAINTENANCE PROJECTS

FY-73

Upper Mobile Bay Channel

Mobile Bay Channel

Fowl River

FY-74

Mobile River Channel (Bankhead Tunnel to Cochran Bridge)

Bayou La Batre

Gulf Intracoastal Waterway (Mile 120-150)

Bon Secour River

Dauphin Island area

When a pipeline is used, it is floated on pontoons and extends from the dredge to the shore or to an area of water disposal. To move coarse material through the pipe, a fluid velocity of at least 12 feet per second (fps) is necessary. Consequently, the larger the discharge pipe, the greater the pump capacity required. The fluid volume moving through a 24-inch pipeline at 12 fps is about 17,000 gallons per minute (gpm) or 37-1/2 cubic feet per second (cfs); with a 28-inch pipeline the volume is about 23,000 gpm or 51 cfs. The pipeline can reach several thousand feet from the dredge and can be extended for greater distances by using booster pumps to overcome friction head losses.

The dredge is held in position during dredging by anchors, swing lines, and spuds. Spuds are long, heavy pipes that are hung from masts near each corner of the stern of the dredge. They pass through openings in the vessel and can be raised or lowered independently. When dropped alternately, they penetrate into the bottom sediments and serve as pivots for the dredge.

Hydraulic dredges are measured by the diameter of the suction pipe. They range from small 4-inch sand pumpers to large 36-inch dredges.

Mode of Operation

Hydraulic pipeline and shell dredges are generally towed to the dredging site and oriented by a tug. When in position, the spuds are dropped, and swing lines and anchors are put out. The anchors are on each side of the dredge; swing lines from these anchors can be tightened

or loosened to swing the bow or suction end of the dredge back and forth in a small arc. During dredging, only one spud is in place at a time. This permits the dredge to move forward as it swings back and forth by "walking" from one spud to the other.

After the pump and cutter-head are started, the ladder is lowered to the desired depth for operation. Channel dredges pump bottom sediments and water through the pipeline to the disposal area. Shell dredges have auxiliary pumps and screens to remove and wash the shells, which are loaded by conveyor belts onto barges. Dredging can be an almost continuous operation except for occasional changes in anchor positions and other operational requirements and breakdowns.

Advantages and Limitations

The chief advantage of a pipeline dredge is the large volume of material that can be moved in a short period of time. Other advantages include the ease of spoil transport, the simultaneous dredging and disposal operation, and the flexibility to perform a variety of dredging operations.

The major limitation of pipeline dredges is that spoil areas must be relatively close to the dredging operation. Another disadvantage is the inability to operate in open or rough water areas. The large volume of materials moved causes a high degree of wear on the cutter-head, pump, and pipeline. Operation is hindered by obstructions in the pump and cutter-head due to buried logs and man-discarded wastes. The anchoring cables and pipeline present a temporary obstruction to navigation in confined channels, and are moved during operations to permit marine traffic.

HOPPER DREDGES

A hopper dredge is a self-propelled, ocean-going vessel designed for hydraulic dredging and transportation of the spoil to a dumping area. Its primary function is to maintain harbor entrances and channels where rough water would make other methods of dredging impractical or impossible.

Hopper dredges are equipped with one or two large centrifugal pumps similar to those employed on pipeline dredges. The suction pipes are hinged on each side of the ship with the intake, or suction, end towards the stern. They are lowered and raised by hoisting cables.

The suction pipes are equipped with a broad scraper, or shoe, that directs or feeds the bottom materials into the pipes as they are dragged along the bottom. Hopper dredges are not equipped with revolving cutter-heads.

Mode of Operation

The dredge moves onto the dredging course, starts the pumps and lowers the suction pipes to the bottom, and continues moving along the course. The shoe on the bottom of the suction pipe scrapes a thin layer of bottom sediments that are drawn up and discharged into the hopper. The sediment tends to settle out in the hopper. The liquid overflow from the hoppers is discharged back into the water. When the hoppers are full, the dredge moves to the disposal site. Large valves in the bottom of the hoppers are opened and the material is flushed out the bottom of the ship. Many trips over the same course are often required to attain the desired depth and width of a channel.

Advantages and Limitations

The chief advantage of a hopper dredge is its ability to operate in rough or open waters. It operates without anchors and causes little obstruction to navigation.

A limitation is that it cannot operate continuously as a dredge because much of its time is spent moving between the dredging site and the disposal area. It also requires a much greater draft than other type dredges.

CLAMSHELL AND DRAGLINE DREDGES

These dredges are float-mounted cranes that use a mechanically operated bucket to remove the bottom materials. The essential components include a barge or float, hoisting machinery, a swinging boom, a bucket, and an anchoring system. Some dredges are also equipped with winches to shift barges to facilitate material disposal.

Buckets are of two general types, the clamshell and the dragline. The clamshell bucket consists of two similar halves that are hinged at the top, similar to its namesake. The bucket can be opened or closed at any time by the dredge operator. The dragline bucket is a large scoop that is dragged across the bottom. Buckets are designed for hard or soft digging materials. Hard digging buckets are heavier and have a more powerful closing mechanism than soft digging buckets. This added weight generally necessitates a reduction in bucket capacity.

Since these dredges are neither self-contained like the hopper dredges nor equipped with disposal pipelines like the pipeline dredges, they either load spoil on barges or must dispose of spoil on immediately adjacent water or land areas.

Mode of Operation

The dredge and its support barges are towed to the dredging site and anchored in position. Positioning equipment may include spuds, similar to pipeline dredges, wires, anchors, and winches to position the dredge along the cut. Materials are brought to the surface in the bucket and are dumped onto disposal sites. If barges are used, the loaded barge is pulled to a disposal site. Usually two or more disposal barges are used so that the dredge can operate almost continuously.

Advantages and Limitations

One of the advantages of bucket dredges is their ability to operate in small or confined areas. This makes them useful in maintaining slips in the harbor areas. These dredges are not limited to shallow dredging depths and are sometimes useful in deep water excavation. Their chief limitation is that they are relatively slow and can move only a small amount of material. They also may require separate disposal equipment.

REGULATION OF DREDGING

Construction and maintenance of navigation channels has historically been under the jurisdiction of the U. S. Army Corps of Engineers. Corps of Engineers permits are required for all non-federal dredging in navigable waters. A public notice is issued by the Corps for each permit application. If an environmental assessment of a proposed project indicates that there will be a significant environmental impact, an environmental impact statement is required. In the case of federal navigation channels, an environmental impact statement is prepared for new projects as well as for the operation and maintenance of existing channels.

In reviewing permit requests, the U. S. Environmental Protection Agency has jurisdiction over water quality and environmental considerations; the U. S. Bureau of Sport Fisheries and Wildlife and the National Marine Fisheries Service assess effects on fish and wildlife. Respective state agencies sharing these responsibilities also review the permit requests. Responsibilities of various agencies are basically defined by federal as well as state law, although judicial and executive rulings sometimes influence dredging projects. On occasion, criteria are established by federal agencies by the issuance of guidelines. Channel dredging projects require that local sponsors provide spoil sites, which is usually accomplished through port authorities, industries, or local or state governments.

Permits for non-federal dredging projects, including shell dredging activities, are issued by the Corps after evaluating effects on

navigation, esthetics, recreation, fish and wildlife and discharge of effluents into navigable waterways which must be in compliance with state and federal water quality standards. State legislatures sometimes impose restrictions on dredging. The regulatory authority and responsibility for shell dredging operations in Alabama, beyond that of the above permitting requirements, are the function of the Alabama Department of Conservation and Natural Resources.

DISCUSSION OF FOUR TYPES OF DREDGING ACTIVITIES STUDIED

To assess dredging activities in Mobile Bay, field studies were conducted to:

- Characterize bottom sediments at various depths in terms of chemical and physical parameters at numerous locations in Alabama estuaries,
- Document water quality in Mobile Bay, Mississippi Sound, and Bon Secour Bay,
- Survey the environmental effects of the following typical dredging projects on the ecosystem of the Bay:
  a. Buried reef shell dredging — Radcliff Materials, Inc.
  b. Open-water spoil disposal — Corps of Engineers maintenance dredging in the Mobile Ship Channel and in the Intracoastal Waterway.
  c. New channel construction in D'Olive Bay — Diamondhead Corporation.
  d. Diked-land disposal — Corps of Engineers, Mobile River maintenance dredging.

Results of the sediment characterization study showed that 26 of 33 sampling locations in Mobile Bay exceeded one or more of the suggested EPA dredging criteria for open water disposal. A comparison of the EPA criteria with study results follows.

Parameter	Suggested EPA Limits (dry weight basis)	Study Results
Volatile Solids	6.0%	38 of 70 observations (54%) exceeded the limit
Chemical Oxygen Demand	5.0%	32 of 70 observations (46%) exceeded the limit
Total Kjeldahl Nitrogen	0.10%	48 of 70 observations (68%) exceeded the limit
Zinc	50 ppm*	35 of 70 observations (50%) exceeded the limit
Lead	50 ppm	5 of 70 observations (7%) exceeded the limit
Mercury	1.0 ppm	1 of 50 observations (0.5%) exceeded the limit
Oil-Grease	0.15%	1 of 4 observations (25%) exceeded the limit.

*ppm = parts per million.

In addition to comparisons with the suggested EPA criteria, analysis of the 70 samples showed that phosphorus ranged from 44 to 1,300 ppm, chromium varied from 4 to 68 ppm, and copper extremes were 1 to 23 ppm. Pesticides, DDE and DDD were detected in 3 of 10 samples at concentrations ranging from 0.59 to 73 parts per billion (ppb), while DDT was found in only 2 of 10 samples at concentrations of 0.73 and 330 ppb. No polychlorinated biphenyls were detected in 10 samples analyzed.

Subsequent to the sediment characterization study, other studies and literature reviews were conducted and are referred to in the following discussions of specific dredging activities in the Mobile Bay estuary.

SHELL DREDGING

Introduction

Shell dredging in Mobile Bay is conducted by Radcliff Materials, Inc., whose operation includes four U. S. Army Corps of Engineers permit areas (Figure 3). The permit areas are located in waters classified for swimming, shellfish harvesting, and fish and wildlife; however, there are no oyster reefs existing within the permit areas as indicated by the 1971 survey by the State. Generally, the usage classifications are higher with increasing distance from Battleship Parkway. Table II shows the percentages of each permit area lying within each usage classification.

Table II

PERCENTAGE OF SHELL DREDGING PERMIT AREAS WITHIN EACH WATER USAGE CLASSIFICATION

PERMIT AREA		WATER QUALITY CLASSIFICATION (%)			
No.	Acres	Shellfish Harvesting	Swimming	Fish and Wildlife	Percentage of permit area in permanently closed* section of Bay
1	3,000	100	--	--	0
2	12,000	22	78	--	78
3	33,000	12	68	20	88
4	8,000	58	42	--	42

*To Shellfish Harvesting

Shell Dredging Permits

Radcliff Materials, Inc., of Mobile, Alabama, and its predecessors have been engaged in the dredging of buried oyster shells in Alabama waters since 1946. This company has been operating continuously since that time through a series of Corps of Engineers permits, renewals, and extensions. The first federal permit for this operation was issued to

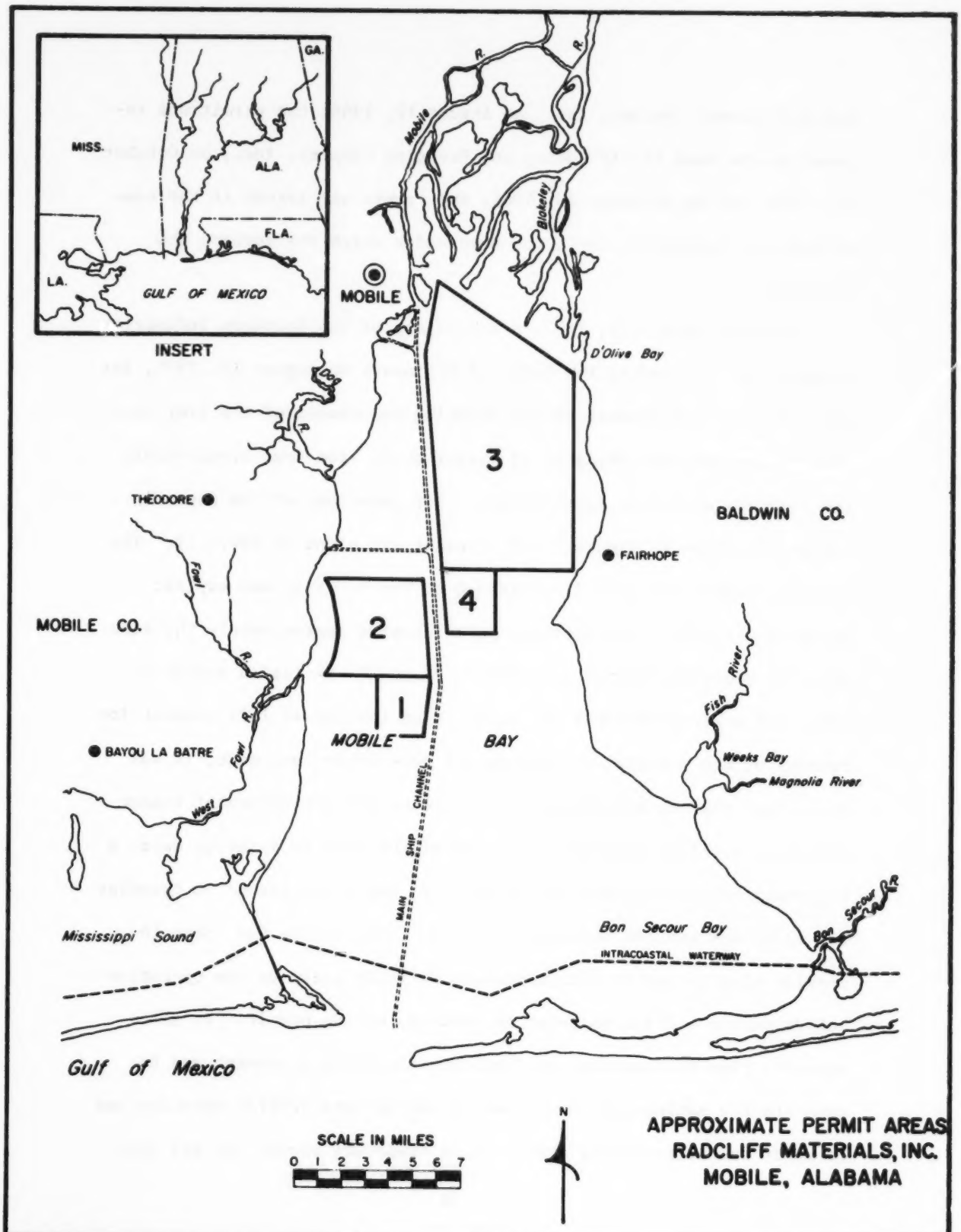
GA.
MISS.
ALA
FLA.
LA.
GULF OF MEXICO
INSERT
Mobile R.
R.
Blakeley
MOBILE
D'Olive Bay
Dog R.
3
THEODORE
BALDWIN CO.
FAIRHOPE
4
2
MOBILE CO.
Fowl R.
1
MOBILE BAY
Fish River
Weeks Bay
Magnolia River
BAYOU LA BATRE
Fowl R.
West
MAIN SHIP CHANNEL
Mississippi Sound
Bon Secour Bay
Bon Secour R.
INTRACOASTAL WATERWAY
Gulf of Mexico
SCALE IN MILES
0 1 2 3 4 5 6 7
N
APPROXIMATE PERMIT AREAS
RADCLIFF MATERIALS, INC.
MOBILE, ALABAMA

FIGURE 3

Radcliff Gravel Company, Inc., on August 12, 1946; the permit was renewed in the name of Bay Towing and Dredging Company, Inc., on October 26, 1949; and on December 29, 1961, the permit was issued in the name of Radcliff Materials, Inc., the name under which the company now operates.

Radcliff Materials, Inc., a subsidiary of the Southern Industries Corporation, applied to the Corps of Engineers on August 17, 1971, for the combining and renewal of two existing Department of the Army permits authorizing the dredging of oyster shell from four areas within the confines of Mobile Bay, Alabama. The locations of the areas involved are shown in Figure 3 and acreages are given in Table II. The previous permit for Area 3 was issued on May 1, 1969, and expired December 31, 1972. The previous permit having approximately the same areas as those designated as Areas 1, 2, and 4 was issued August 6, 1968, and expired December 31, 1971. When the August 1971 request for renewal of the permits, to include all four areas, was made, it was determined that an environmental assessment and environmental impact statement would be required. Because of the lack of existing data, a temporary one-year permit for Areas 1, 2, and 4 was issued on December 14, 1971, and expired December 31, 1972. This action was taken to provide time to gather data necessary to fully evaluate the operation before making a final decision on issuance of the permit. To allow adequate time to complete the final environmental statement and to complete the administrative review by appropriate federal agencies and to study the alternatives available, a temporary permit for all four

areas was extended for an additional four months, to April 30, 1973. On April 30, 1973, the Secretary of the Army authorized issuance of the permit to Radcliff Materials, Inc., for continued shell dredging in the four areas. The permit, to expire on December 31, 1976, was issued with the following restrictions:

1. Only one dredge to be operated in the bay at any one time;
2. The Commissioner, Alabama Department of Conservation and Natural Resources, shall be notified at least one week before the dredge is moved into a new cut and at least four weeks before the dredge is moved to a new permit area;
3. No dredging to be done within 2,500 feet of any federal navigation channel;
4. No dredging to be done within 2,500 feet of any natural oyster reef as established by Act of the Legislature of Alabama, [Alabama Code, as amended, Title 8, Section 118 (1940)] and as physically located by personnel of the Alabama Department of Conservation and Natural Resources;
5. No dredging to be done within 10,000 feet of any shoreline;
6. Dredge spoil discharge shall be directed by pipe, flume, or other conduit to within three feet of the natural bottom elevation; and
7. All mounds which may accumulate adjacent to dredge cuts as a result of the permitted operation shall be leveled to restore the original bottom contour and depths.

The present agreement of Radcliff Materials, Inc., with the State of Alabama is through a lease arrangement that became effective December 1, 1960 (made in the name of Bay Towing and Dredging Company, Inc.) which expires November 30, 1975, with an option to renew for an additional five years.

Effects

Shell dredging in Mobile Bay is conducted outside of channels in the open estuary on a practically continuous basis. Dredged material is screened and washed to remove the shell. The discharge, composed mostly of original bottom material, is returned overboard in the immediate vicinity of the dredge and over the cut from which it was taken, except for approximately 200 feet of the initial cut. The dredging process leaves a series of shallow ridges and valleys. Studies have shown that within a year, current and wave action tend to fill most cuts, and the mounds tend to even out. The mud flow discharged from adjacent cuts also contributes to the filling process.

Turbidity of water is attributable to suspended and colloidal matter distributed throughout the water column. Turbidity is a measure of the extent to which the intensity of light passing through a liquid is reduced by the suspended matter. In much of the older literature on the effects of dredging, "turbidity" and "suspended solids" are used almost synonymously and much of this work cannot be compared with current standards. The degree of turbidity is not a measure of the concentration (or quantity) of suspended solids. It has been shown that the visible plume has little or no relationship to sedimentation both in the open bay and near shore.

The most obvious effect of the discharge from the dredge is a turbidity plume of varying length and width. The immediate effect of the turbidity plume is the reduction of light penetration in the water column and a temporary theoretical reduction in the photosynthetic rate of planktonic and benthic flora. Studies in other areas have shown that the primary productive capacity of estuaries is principally from marshes and tributary streams, and not the open water area.

Studies in Mobile Bay and other estuaries have indicated that surface turbidities from dredging operations approach normal levels within 1,200-1,500 feet from the point of discharge. Ambient wind and water conditions determine the existence and extent of a visible plume. A visual inspection during wind velocities of 12 to 15 knots revealed that the plume from the shell dredge retained its identity for a distance exceeding 1.5 miles.

When sediments are brought into an estuary by a river or are resuspended by some natural or artificial activity, the coarser materials, which include shell fragments, sands, and some coarser silt particles, settle very rapidly. The suspended particles made up of finer silts and clays flocculate to form agglomerates, until they become large enough to settle under local hydraulic conditions. Although the shell dredge does not introduce sediments into the bay, it does resuspend materials present in the bay bottom which in most instances have been isolated from the day-to-day bay ecosystem for a long period of time.

Potential for deleterious siltation effects from open-water dredging can be judged on the basis of the deposition of suspended solids.

Data for Mobile Bay show that 90 percent of the materials suspended by the dredge fall out immediately under the discharge and 96 percent within 200 feet. On a calm day, suspended solids at the surface were less than 100 mg/l beyond 400 feet from the discharge. The average surface suspended solids for Mobile Bay (27 mg/l) were not exceeded beyond 1,200 feet. At mid-depth, values over 100 mg/l extended out to 800 feet. Ambient conditions were exceeded a maximum distance of 2,000 to 2,800 feet from the dredge. In open-water shell dredging, as conducted in Mobile Bay, most of the solids go back into the cut trench so that high spoil banks and deep channels are generally not created. On bottom,on a calm day, concentrations above 1,000 mg/l extended a maximum of 1,000 feet from the discharge. Values over 100 mg/l were limited to a maximum of 1,200 feet. On a windy day (25 knots), values over 1,000 mg/l were found out to 2,000 feet, two feet above bottom. Six inches above bottom,concentrations as high as 22,000 mg/l extended as far as 1,600 feet from the dredge. Background was not greatly exceeded beyond 2,000 feet. Studies in other bays have reported silt distribution at similar distances to those observed in Mobile Bay.

The most significant conditions produced during dredging are due to sediment density layers (density currents or mud flows). The two primary factors which cause mud flows are the kind and amount of particles resuspended. Such layers of mud frequently form during recovery of shell when the overburden is other than sand. Because of the very fine sediments covering the bay bottom, mud flows are the rule rather than the exception during either shell or channel dredging.

For the mud flow to form under undisturbed conditions, sediment concentrations greater than 10 grams per liter are required so that the settling of the layer is hindered. The layer then moves away from the dredge as a fluid mud near the bottom. Movement of this layer is controlled to a large extent by gravity. The mud flow is capable of moving in directions other than indicated by either bottom or surface currents. The thickness of the layer is reduced with increasing distance from the dredge and with time. Until concentrations are in excess of 175 grams per liter and consolidation occurs, mud flows are subject to movement by gravity and to a lesser degree by tidal or wind action.

Documentation has shown mud flows to extend about 1,600-2,000 feet from shell dredges. Work in Mobile Bay and in Texas demonstrates the effectiveness of previous dredge cuts and trenches in intercepting and trapping the mud flow. The mud flow covers the original bottom from one to several inches and some organisms capable of migrating up through it survive. Organisms which may be lost include the sessile and burrowing invertebrates such as polychaete, oligochaete, and nemertean worms, some mollusks, and crustaceans. Bottom-dwelling algal forms may also be covered and lost.

Bottom topography plays an important role in the movement of mud flows. Oyster reefs which protrude above the bay bottom tend to either deflect or resuspend mud flows and are not greatly susceptible to sediment deposition from this source.

Increases in suspended solids from dredging may provide habitat and particulate food for both oysters and shrimp. In Mobile Bay, shrimp trawlers often operate in close proximity to the shell dredge.

The effect of the dredging operation on dissolved oxygen concentration is pronounced in the area surrounding the dredge. There is an immediate oxygen demand when the sediments are dispersed. Dissolved oxygen at surface and mid-depth have been observed to be only slightly depressed. A regimen of low dissolved-oxygen concentrations, in a state of active exertion, surrounds the dredge in the mud flow. On the bottom, this condition has been observed to extend for approximately 800-1,700 feet from the dredge.

The exchange mechanism of trace elements between sediment, water, and biota is largely unknown. Metals in the sediment are strongly adsorbed on fine silt and clay particles. Dredging was not observed to increase dissolved metal concentrations in the water. Aqueous concentrations decreased in some cases, undoubtedly as a result of adsorption on the briefly suspended silt and clay particles.

Total coliform bacteria are more abundant in sediments than in the water column. Sediment disturbance temporarily resuspends these organisms, but because of the bacteria's affinity for sediment, particularly organics, the bacteria settle out with the suspended matter. Since aerobic bacteria are more abundant in the top few centimeters of the sediment, any bottom disturbance causes their resuspension. The total bacterial contribution to the bay as a result of sediment resuspension by shell dredging is insignificant when compared to the area's

land runoff and point pollution sources. Opening and closing of the oyster beds as a result of changes in coliform levels are directly correlated with river input, and no effect of shell dredging on this parameter has been demonstrated.

If proper precautions are taken to avoid damage to oyster beds, effects of shell dredging on water quality, substrate and resident biota are temporary. Study data indicate that substantial numerical recovery of the benthic fauna in dredged cuts occurs within two months to two years. However, species diversity may be decreased for a longer time. These studies also show that recovery begins soon after dredging, and some benthic forms begin to repopulate the cuts within 30 days.

Because of substrate characteristics, salinity fluctuations, and the frequent occurrence of anoxic conditions, the section of Mobile Bay which includes major portions of the shell dredging permit areas has a depauperate benthic fauna of low diversity. The bottom of Mobile Bay supports a community of consumers primarily at the scavenger and decomposer levels. Temporary changes over very small bay areas in the function and characteristics of this community would not have an appreciable effect on overall productivity of the bay ecosystem.

Shell dredging operations should only take place under close supervision by the state that owns and administers both the live oyster and shell resources.

CHANNEL DREDGING

Introduction

Channel dredging is performed to construct or maintain navigation channels. Maintenance of existing channels, for the most part, is contracted to private firms. Hydraulic dredges are usually employed for this operation. Recent alluvium and water are pumped from the bottom of the channel and the spoil is discharged by pipeline some distance away from the channel in open water or on shore. If draglines are employed, the spoil is normally deposited along the bank.

The major dredging projects in coastal Alabama involve maintenance of the 40 x 400-foot Mobile Ship Channel and the 12-foot deep Gulf Intracoastal Waterway (Figure 1). The intracoastal waterway is 125-feet wide east of the ship channel in Bon Secour Bay and 150-feet wide west of the ship channel toward Mississippi Sound. These projects utilize both upland spoil disposal to diked areas and open-water disposal adjacent to the channels. Additionally, hopper dredges are employed to maintain the Mobile Bar Channel where spoil is disposed of in the Gulf of Mexico.

Construction of the Mobile Ship Channel began in 1827. Between that date and 1870, a 10-foot channel was maintained through the shoals at the mouth of the Mobile River at the head of the bay. Beginning in 1880, the entire channel was deepened to 17 feet. The channel depth was increased to 27 feet beginning in 1889 and was periodically deepened and widened until its present dimensions were reached in 1965. In total, some 451,000,000 cubic yards of material

have been dredged to date in constructing and maintaining the ship channel, with the vast majority being spoiled along both sides of the channel, creating significant spoil banks. The lighter material removed during maintenance dredging is not thought to greatly contribute to the present height of the spoil banks.

The present dimensions of that portion of the intracoastal waterway in Mobile and Bon Secour Bays were reached in 1943. The 12-foot depth requires maintenance dredging of about 3 miles east of the Dauphin Island bridge and about 13 miles in Bon Secour Bay. An approximate 10-mile reach between these two sections requires no dredging as natural depths are sufficient for project dimensions. Approximately 8,500,000 cubic yards of material has been dredged with the majority of the material being placed along the channel.

Mobile Bay, with an average depth of about 9.7 feet, has been shown to be well mixed thermally and moderately stratified in terms of salinity. This is typical of shallow Gulf Coast bays. Mobile Bay, however, has large areas of the bay bottom which are somewhat deeper than the surrounding bottom and contain water masses stratified by salinity. Oxygen depletion occurs in the bottom waters of these areas during the warm summer months as a result of oxidation of organic material, salinity stratification, and the lack of mixing of water masses. The stratified water masses with depressed oxygen concentrations are not mixed by normal tidal movements or by winds less than 10 knots. In these instances, stratification may result from salinity

differences of only a few parts per thousand. Low dissolved oxygen has been observed to exert a considerable influence on the fishery resources of the bay.

The bathymetry of Mobile Bay prior to major alteration by construction of the ship channel indicates that the bay was relatively flat, sloping gently toward its mouth. Current bathymetric data show large shallow depressions in the bay bottom bounded by spoil from construction of the ship channel and shoaling in the lower bay. Spoil from the channel protrudes above and near the water surface along the channel in the extreme upper end of the bay. Generally, the spoil banks are less than 1.5 feet high over the lower half of the bay and are near bottom contours in the extreme lower end. The shoaling which occurs across the lower bay from the ship channel into Bon Secour Bay creates an even less pronounced barrier of about one foot above existing bottom.

Additional field work will be required to more completely demonstrate the influence that the channel and spoil banks have on water circulation. The Corps of Engineers has recently constructed a large, scale model of the Mobile Bay System at the Corps' Waterways Experiment Station in Vicksburg, Mississippi, and is presently studying, among other aspects, the circulation patterns of the bay. Upon completion of these studies more definitive information regarding the influence of the construction and maintenance of the ship channel on circulation in the bay will be available. The

ship channel, spoil banks, and shoaling in the lower bay appear to emphasize salinity stratification and deteriorated water quality. However, the apparent existence of depressed dissolved oxygen conditions before construction of the ship channel, as evidenced by the long history of jubilees, indicates that the present physical modifications to the bay are not the sole causes of the existing water quality conditions.

Effects

Maintenance channel dredging operations observed in Alabama were in the Mobile Ship Channel and the Gulf Intracoastal Waterway. Both maintenance projects employed open-water spoil disposal adjacent to the channels. The effects of channel dredge discharge are generally similar to those observed for shell dredge discharge, and much of the general discussion of the section pertaining to shell dredging is applicable to channel dredging.

Turbidity on the surface around the discharge of the ship channel dredge did not exceed 100 JTU beyond 200 feet nor 50 JTU beyond 400 feet. Ambient turbidity (15 JTU) was slightly exceeded out to a distance of 1,200 feet in the down current direction. At mid-depth, values over 100 JTU were limited to a distance of 400 feet and values over 50 JTU extended to a maximum distance of 1,200 feet in one direction, but were otherwise confined to within 600 feet. Turbidity measurements were not taken around the discharge of the intracoastal waterway dredge.

Samples were taken at surface, mid-depth and near bottom around the ship channel dredge for suspended solids analyses. Total suspended solids at the surface slightly exceeded ambient levels out to 1,000 feet from the discharge. Values in excess of 100 mg/l were limited to within 400 feet. The concentration was reduced 92 percent within 100 feet and 98 percent within 200 feet which indicated rapid settling. At mid-depth, concentrations over 100 mg/l extended out to 400 feet and values of 50 mg/l extended to a maximum of 1,200 feet from the discharge. Ambient levels were slightly exceeded out to 1,400 feet in some directions. On the bottom, concentrations over 1,000 mg/l extended out to at least 1,800 feet from the discharge. Ambient levels were exceeded at all bottom stations sampled which were extended out to only 1,800 feet.

The majority of the sediment pumped from the ship channel, other than that which was deposited immediately under the discharge of the pipeline, was transported near bottom as a mud flow. Concentrations of 10,000 mg/l were limited to within 400 feet of the discharge.

Suspended solids from the effluent of the intracoastal dredge did not exceed ambient concentrations at surface or mid-depth beyond 400 feet or on the bottom beyond 800 feet. The smaller zone of influence and the lack of a mud flow beyond about 200 feet experienced by the intracoastal dredge in comparison with the ship channel dredge was apparently due to coarser material being pumped and a smaller discharge volume.

Volatile solids in the effluents of both dredges settled very quickly and were transported near bottom proportional to the distribution of inorganic suspended solids.

The extent of low dissolved oxygen caused by these two dredges was limited to the mud flow near bottom.

The pH was slightly lowered in the discharge pipes of both dredges and was less than ambient out to 200 feet from the point of discharge from the ship channel dredge. The maximum reduction in pH observed around the channel dredge was 1.3 units, but the average was only about 0.5, which is less than normal diurnal fluctuations. No measurable change in pH was observed around the intracoastal dredge from the point of discharge. This small and limited change in pH had no measurable effect on other water quality parameters.

Analysis for phosphorus was performed only on samples collected from the intracoastal dredge. A single line of samples showed no phosphorus increase in settled samples. The discharge from both dredges was not observed to increase the levels of dissolved heavy metals.

NEW CHANNEL DREDGING IN D'OLIVE BAY

Introduction

D'Olive Bay is located at the northeastern edge of Mobile Bay (Figure 1). The bay is about one mile long and 0.4 miles wide, with an average depth of about three feet. Extensive shoal areas occur in the upper half of the bay and surround the tip of the peninsula separating Blakeley River and D'Olive Bay. D'Olive Creek enters the bay at the northeastern corner. Blakeley River water enters the bay

at the northwest and southwest corners. The shallowness and orientation of D'Olive Bay make it especially susceptible to tidal, wind and river influences.

D'Olive Bay was selected for study because it was the site of new channel dredging in the Mobile Bay estuarine system. This investigation was concerned with identifying and describing the effects of the dredging project on water quality and biota. The project consisted of a 7-foot channel approximately 1,800 feet long and a turning basin having a length of about 1,200 feet. Approximately 100,000 cubic yards of material were dredged over a 2½-month period. An 8-inch dredge was used during the months of June and July, while an 18-inch dredge was used the final two weeks of the project which ended around the middle of August 1972.

Spoil from the channel was pumped into an adjacent diked land area. No salt marsh was affected by spoil disposal. A weir discharged spoil effluent from the diked area into D'Olive Bay, but the very low flow from the weir during the study precluded effective examination of the weir overflow.

The sequence of study was: Phase I — prior to dredging; Phase II — during channel dredging; Phase III — immediately after dredging was completed; and Phase IV — eight months after completion of the dredging project.

Effects

In general, channel dredging in D'Olive Bay had no significant effects on circulation patterns, water temperature, dissolved oxygen,

salinity or turbidity except where mud from a dike failure created an unstable bottom condition. Core samples of bottom sediments showed that concentrations of volatile solids, COD, TKN, zinc and lead exceeded suggested EPA dredging criteria for open-water disposal of dredge spoil. Heavy siltation had been caused by runoff from nearby construction sites unrelated to dredging, as well as the dike failure. Frequent winds in the area caused resuspension of silt and clay sediments to generate abnormally high turbidities.

There were only temporary localized turbidity increases around the dredge operation itself. A silt plume extended 300 feet from the cutter-head of the dredge, while no plume was observed at the weir discharge site. High turbidities were not experienced above or below the channel operation either during or after dredging.

Phytoplankton productivity estimates in D'Olive Bay ranged from 0.37 gC/m^2/day in October 1972 to 5.02 gC/m^2/day in July 1972. Phytoplankton density and organic production were considerably higher in May 1973 than in April 1972, even though average turbidities were also higher. Total primary production in D'Olive Bay during the early summer was considerably higher than pelagic productivity as a result of submersed grass blooms.

Depressed dissolved oxygen concentrations, which at times existed uniformly throughout D'Olive Bay, were not attributable to the dredging operation. The disruption of most of the grass beds and increased turbidity appeared to be associated with increased salinity and a strong

two-day west wind. Natural conditions had a greater short-term impact on the bay environment than did channel dredging.

The most serious ecological consequence of channel dredging in D'Olive Bay was related to mechanical destruction and disruption of benthic communities. Approximately 13 acres of benthic communities in the channel path were affected. Additionally, benthic communities in approximately 7 acres of the bay were covered and destroyed when a dike failure released spoil into the bay. These areas supported fewer animals at least eight months after dredging was completed. Benthic animal biomass at seven affected stations was 28 percent lower than at control stations. Submersed grass standing crop at a station in the path of the mud flow was less than 15 percent of the level eight months before the dike break.

DIKED DISPOSAL

Introduction

In land disposal from a pipeline dredge, the spoil is generally discharged into an upland diked area. The dredge effluent is retained in the basin for settling of suspended solids and the water is returned to the receiving water course.

Diked land disposal in the Mobile Bay Estuarine System is largely confined to disposal of spoil from maintenance dredging of the upper Mobile Bay Ship Channel and the Mobile Harbor facilities. Additionally there are other small projects around the periphery of the bay which employ this method of disposal. The selection of land disposal sites is coordinated with responsible federal and state agencies.

Investigation of Diked Land Disposal

An investigation of the effects of dredging and diked land disposal on water quality was conducted in March 1972. During this period, a hydraulic dredge performed maintenance dredging operations in the Mobile River Harbor. This study has not been completed; however, the preliminary results are herein reported for information. It is the feeling of the committee that these findings are tentative and, therefore, the committee drew no conclusions from the data. Upon completion of detailed analyses, it is expected that the Corps of Engineers, Waterways Experiment Station will publish the final results.

Data show that dredging in Mobile River caused a decline in dissolved oxygen and pH levels in the pipeline discharge but not in the water returned to the river (Table III). Dissolved oxygen dropped to less than 1 mg/l at the dredge discharge indicating the immediate oxygen demand associated with the bottom sediments. The dissolved oxygen was near saturation limits at the outlet weir. The pH dropped about a unit from the inlet to the discharge end of the pipe, and returned to normal study levels at the discharge weir. Salinity values showed only small change on passing through the dredge-diked area system.

Turbidity data indicate that the diked area reduced the highly turbid dredge discharge waters to an average only 24 units above river values. The diked area was approximately 50 percent efficient in removing color imparted to the water during the dredging operation.

Dredging appeared to increase the ortho-phosphate level from the inlet to the discharge. However, the value had dropped below detec-

Table III

Analyses of Diked-Land Disposal Samples

(Average Concentrations)

	STATION 1 Cutterhead (35')		STATION 2 Dredge Discharge		STATION 3 Outlet Weir		STATION 4 Mobile River (20')	
	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
DO (mg/l)	--	6	--	<1	--	7.6	--	8.7
pH	--	8	--	7	--	8.1	--	8.1
Salinity (o/oo)	--	28	--	24	--	22	--	0.6
Turbidity (JTU)	46	--	Off Scale	--	70	--	45	--
Color (units)	--	137	--	Off Scale	--	272	--	151
O-Phosphate (mg/l)	--	0.13	--	0.46	--	0	--	0.07
COD (mg/l)	54	42	96	62	107	84	34	30
TKN (mg/l)	0.47	--	18.6	--	25.0	--	0.52	--
Volatile Solids (mg/l)	2131	1976	4191	2234	4297	3315	94	83
Mercury (ug/l)	3.2	1.0	2.4	0.8	1.8	0.8	2.0	1.3
Zinc (mg/l)	0.17	0.06	0.24	0.05	0.09	0.03	0.06	0.03
Lead (mg/l)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

mg/l = ppm
ug/l = ppb

Waterways Experiment Station

table limits at the weir outlet. Further interpretation of the data is needed to explain this result. Total Kjeldahl nitrogen (TKN) showed a marked increase from the dredge inlet to the discharge. TKN also showed an increase upon reaching the outlet weir.

Volatile solids were found to be mostly (90 percent) in the dissolved phase. As shown, volatile solids were much higher in the deep (35-foot) saline water than in the shallower (20-foot) fresh water. Further examination of the data is needed for all the indicators of organic material (COD, TKN, and volatile solids) to gain an understanding of the nature and behavior of the organic materials.

Mercury analyses indicated that most of the mercury (70 percent) exists in the particulate phase. Analyses indicate that the mercury decreased while passing through the dredge system. Zinc appeared to exist primarily in the particulate phase and showed a slight decrease on passing through the dredge-diked area system. It should be noted that the highest levels of zinc were found in the deep saline waters. Lead was found at the lower limits of detection and showed no increase due to dredging.

No difficulties were experienced with the structural integrity of the diked land disposal system for the Mobile River investigation. However, a dike failure did occur during the D'Olive Bay investigation. Inquiries into diked spoil disposal practices revealed that dike failures frequently occur. This points out the need for development of adequate design and operation criteria for diked land disposal systems and for proper inspection and monitoring procedures by appropriate agencies.